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STUDY OF PROGRESSIVE COLLAPSE ANALYSIS OF TRANSFER GIRDER SYSTEM RCC BUILDING

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ABSTRACT

The structural behavior and analysis of multi-storey building components and supporting transfer girders have received added emphasis due to its importance in connection with buildings. The supporting transfer girder acts either as a full tension member, deep beam or as an ordinary beam in bending depending on the type of upper structure form and there relevant parameters such as span/depth ratio of the transfer girder, stiffness of the support columns, span of the shear wall. Progressive collapse is one of the main reasons for the failure of structure. It occurs due to removal/ damage of a column or a shear wall by fire, blast or vehicle impact. In this study, G+8 multi storey transfer girder system concrete building was analyzed using ETABS to predict the sensitivity of the structure to progressive collapse .Progressive collapse load combination was adopted as per GSA guidelines. Corner, edge and intermediate columns were removed separately at ground level and basement of the building. Viscoelastic dampers are used for improving performance of building during earthquakes. In the present study, effect of viscoelastic dampers on progressive collapse resistance reinforced concrete frame structure building is evaluated. This study can be useful for important structures.

Key words: Progressive Collapse, GSA Guideline, Viscoelastic Damper, Time History function

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1. INTRODUCTION

The term progressive collapse has been used to explain the spread of an initial local failure in a manner similar to a chain reaction that leads to partial or total collapse of a building. Progressive collapse occurs when a structure has its loading pattern or boundary conditions changed such that structural elements are loaded beyond their capacity and fail. In order to prevent the progressive collapse, structure should be capable for providing alternate load path to redistribute additional forces, when one or more column is removed.US General Service Administration (GSA) [1] and Department of Defense guidelines (DoD) have issued design and analysis guidelines for progressive collapse evaluation of building structures. The supporting transfer girder acts either as a full tension member, deep beam or as ordinary beam in bending depending on the type of upper structure form and their relevant parameters such as span/depth ratio of the transfer girder, stiffness of the support columns, span of the shear wall In passive energy dissipation system the motion of structure is controlled by installing devices to structure which can suitably modify stiffness, mass and damping properties of structure. Passive energy dissipation devices can be effective against winds and earthquake induced motion.

Marjanishvili and Agnew [2] studied four different analysis procedures. The load was increase by a factor which results DCR value near to 3 and all the four procedure were carried out for various cases deflection and rotation were measured.Kima and Kimb [3] presented two types of analysis model structure to assess potential for progressive collapse. Gravity load resisting system (GLRS) in which gravity load was resisted by steel moment resisting frames while lateral load was resisted by shear walls. Lateral load resisting system (LLRS) in which steel moment frames were designed to resist both gravity and lateral loads. Linear static analysis was performed on the structure assigning the hinge to the member and was rerun until DCR value was exceeded the limiting value for three different column removal (corner, second left, center) scenario for GLRS and LLRS structure using both guide lines. Tavakoli and Alashti [4] considered 3D and 2D models of multi-storey MRF steel structure. Pushover analysis was performed on these models, with different locations of column elimination, the hinge rotation in beams and columns was checked and compared with progressive collapse acceptance criteria. Target displacement was applied to all the four structures and it was found that all the column remain in elastic region and did not exceeded collapse prevention (CP) level.

Rahai et al. [5] evaluated the performance of the RC load bearing wall 10-story structure under progressive collapse. The load bearing walls were removed at various locations in different stories and vertical displacement were found at various joints. It was found that potential of collapse increases where the cross-section of member is changed. Ren et al. [6] considered two typical 15-storeyed building models designed with equivalent overall lateral resistance to seismic actions. Building A was a weak wall-strong frame structure while building B was a strong wall-weak frame system. For building A, the analysis results indicate that progressive collapse does not occur when the shear wall is removed from any representative story. For the prevention collapse of building B the linear static and nonlinear dynamic method was rerun by increasing the reinforcement in the critical section until it reached collapse resistance. Jinkoo Kim and Sung hyuk Bang [7] studied a strategy developed for an appropriate plan-wise distribution of viscoelastic dampers to minimize the torsional responses of an asymmetric structure, with one axis of symmetry subjected to an earthquake-induced dynamic motion. The modal characteristic equations of a single-storey asymmetric structure with four corner columns and added viscoelastic dampers were derived, and a parametric study was performed to identify the design variables that in uence the torsional responses. Based on the results of parametric study, a simple and straight forward methodology to find out the optimum eccentricity of added viscoelastic dampers to compensate for the torsional effect of a plan-wise

asymmetric structure was developed using modal coefficients. The results indicates that the torsional response of asymmetric structures can be reduced significantly following the proposed method, and that the viscoelastic dampers turn out to be more effective than viscous dampers in controlling torsional response of a plan-wise asymmetric building structure.

2. METHODOLOGY

A 9 storey 3D building was modeled (Figure 1) for this study in Extended 3D Analysis of Building System (ETABS 2015) software, which can perform design and analysis of structures. Type of Building was a RCC moment resisting space frame residential building with. Plan of the model was irregular in shape with reentrant corners. The data used for analysis of building is shown in Table 1.

Table 1 Basic Data of the building

Member	Size
Typical Storey Height	3m
Beam	250mm * 400 mm
Ground floor Beam	250mm * 700mm
Column	400mm *400 mm
Ground floor Column	600mm *600mm
Slab Thickness	150 mm
Seismic Data	
Seismic Zone	3
Response Reduction factor	3
Importance factor	1
Damping	0.05
Time period (X- dir.)	0.4236
Time period (Y- dir.)	0.4955

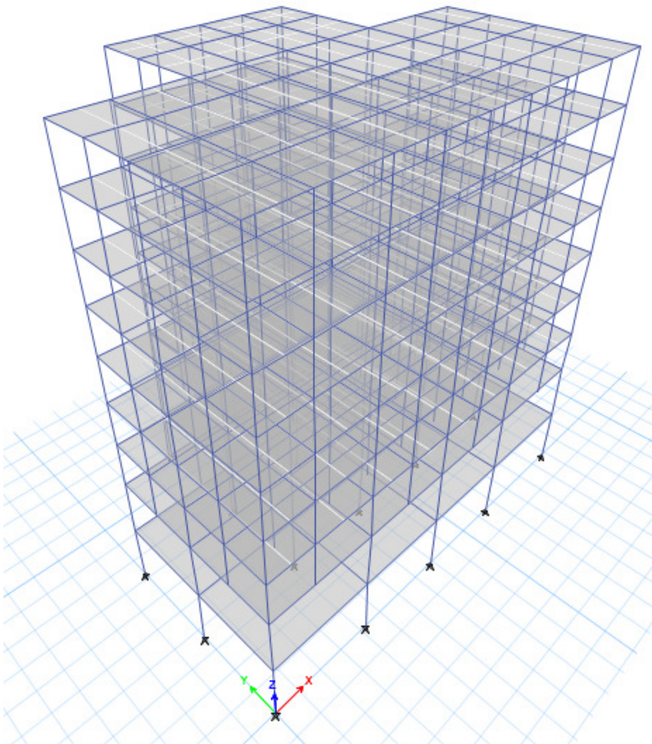

Figure 1 3D Model of building

The loads and loads combination were taken as per Indian Standard IS 400. Live load was taken as 3 kN/m2 on slab and dead load of wall was taken as 12 kN/m on primary beam.

Table 2 Load combination

Sr No	Load combination
1	1.5 (DL + LL)
2	1.2 (DL + LL ± EQx)
3	1.5 (DL ± EQx)
4	(0.9DL ± 1.5EQx)

As per GSA guideline, Linear static analysis (LSA) approach can be applied when building has less than 10 storey. In this approach the load combination can be taken 2(DL + 0.25LL).If the structure is irregular, a linear static procedure may be performed if all of the component DCR (Demand to capacity ratio) determined are less than or equal to 2.0.If the structure is irregular and one or more of the DCRs exceed 2.0, then a linear static procedure cannot be used.GSA guideline suggested Linear Dynamic Analysis (LDA).In this approach involves real-time removal of load carrying structural elements. It is more appropriate to refer to this method of analysis as a time history analysis. The frame is assumed to be at rest in its original configuration, and then subjected to a sudden column removal. The load combination can be taken (DL + 0.25LL).Reaction is applied at the column removal location and time history function is defined for this analysis as RAMP DOWN. At t = 0, f (t) = 1, and at t = 0.002, f (t) = 0, also at t = 1, f (t) = 0.

Viscoelastic dampers has been used successfully in several high rise building for the effective reduction in earthquake and wind induced response. Design procedure illustrates the parameters like number, size and required properties of damper for any structure to achieve target structural response. The design is carried out according to standard available literature [7], which recommends Kelvin Model for analysis. Damper pro initially design of viscoelastic damper is carried out for specified amount of damping and the calculated properties are used to model viscoelastic damper in Etabs through nonlinear link properties. In this paper a strategy developed for an appropriate plan-wise distribution of viscoelastic dampers to minimize the torsional responses of an asymmetric structure, with one axis of symmetry subjected to an earthquake-induced dynamic motion. Figure 2 shows location of the viscoelastic damper.

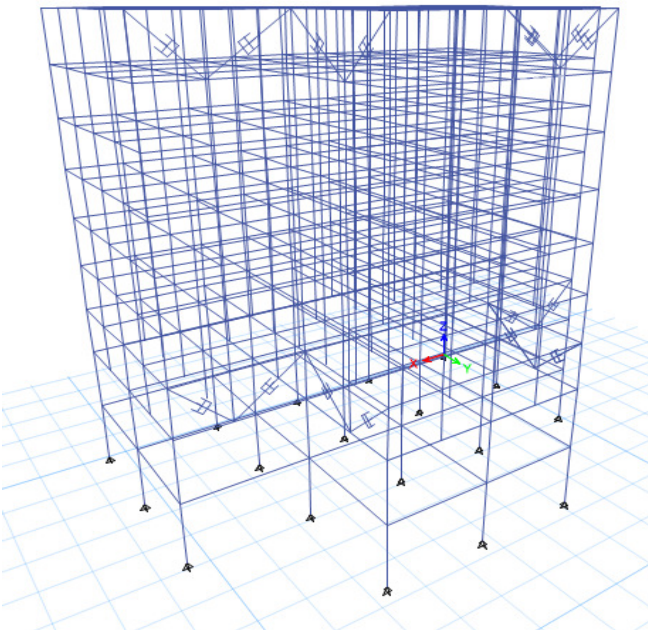

Figure 2 Location of viscoelastic damper in building

3. RESULT

In study a column removed which were gives support to transfer girder at corner, edge intermediate and rentrant corner location of building. Floor. As per GSA guide-line the DCR of each element should be less than 2. If the DCR value exceeds 2, the progressive collapse will occur. The progressive collapse gets started at members which are supported by column.

Figure 3 and figure 4 are represent the DCR of beam and DCR of column before column removal in the building. According to Figure 3 and figure 4 the DCR value is less than 1 so the building is safe under all conditions.

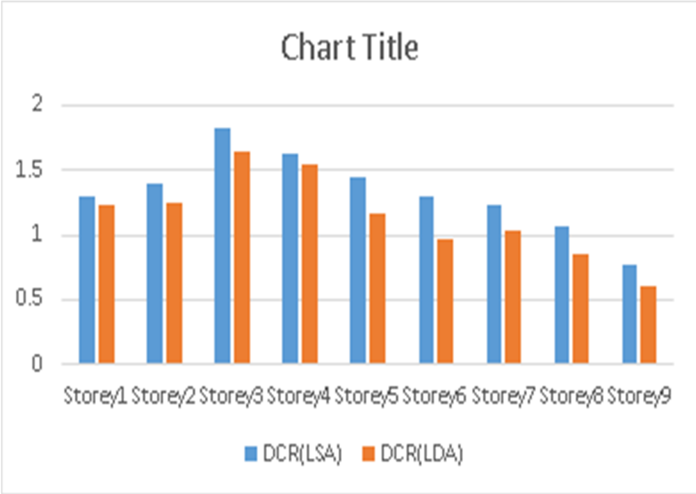

Figure 3 DCR of beam before column removal

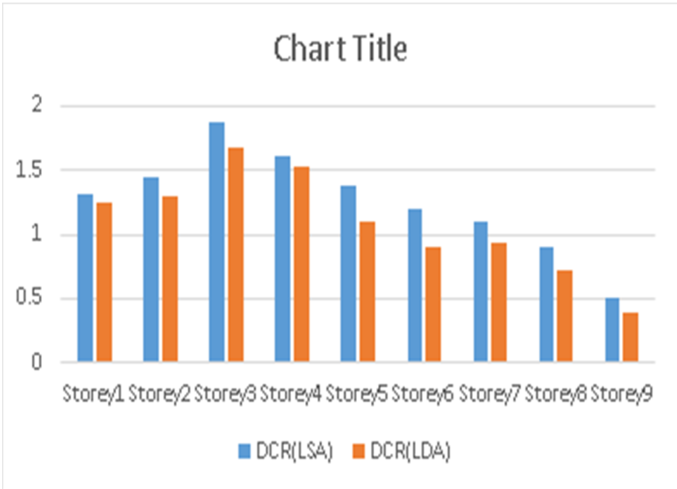

Figure 4 DCR of column before column removal

Figure 5 to figure 8 represent the DCR of beam at Column Removed at Corner column, edge column, intermediate column and rentrant column respectively in building without dampers using LSA and LDA approach.

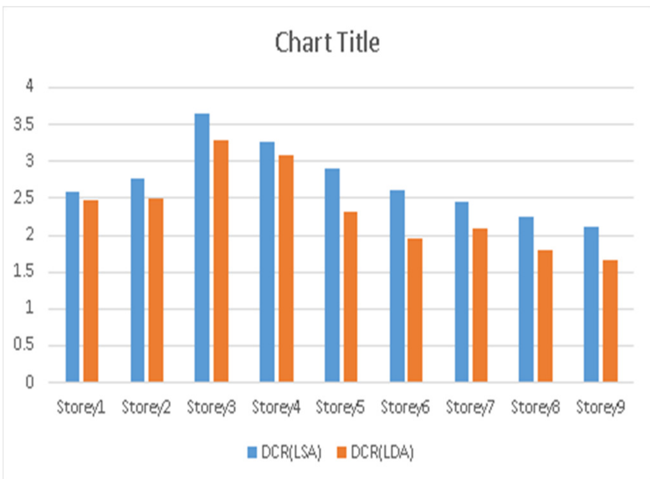

Figure 5 DCR of beam at Column Removed at Corner column

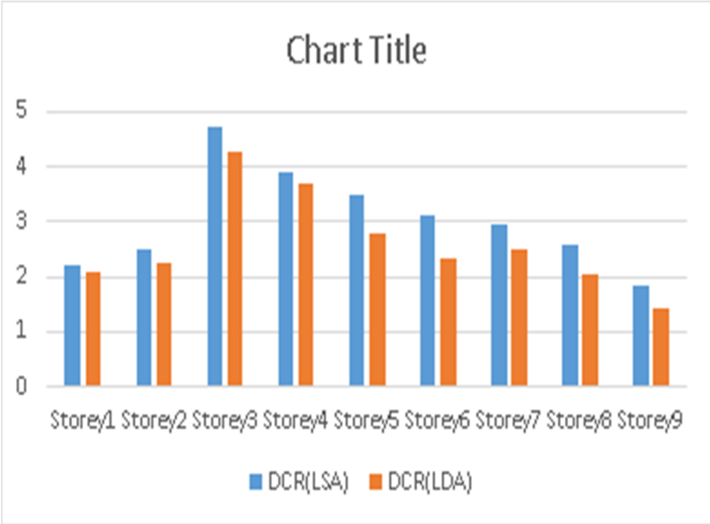

Figure 6 DCR of beam at Column Removed at edge column

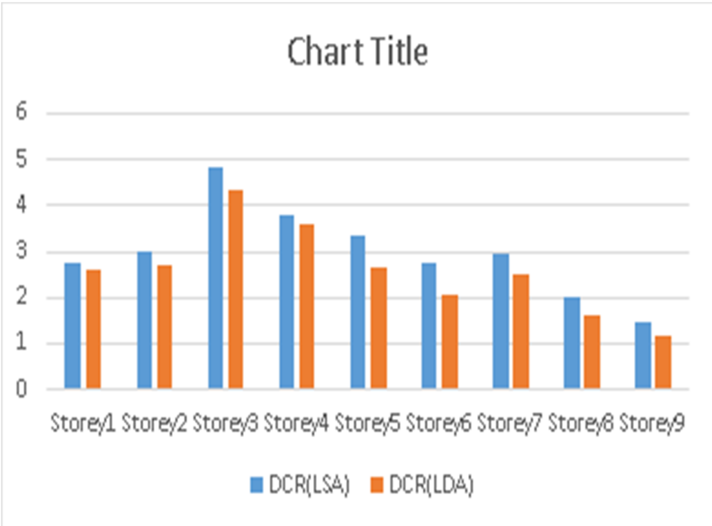

Figure 7 DCR of beam at Column Removed at intermediate column

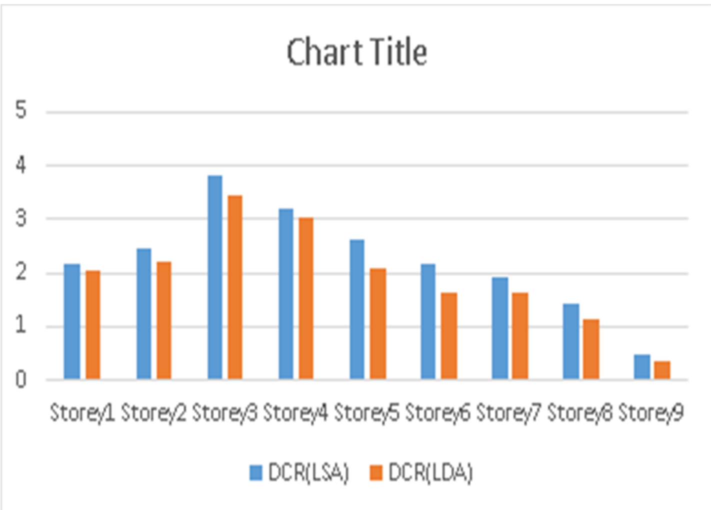

Figure 8 DCR of beam at Column Removed at rentrant column

Figure 5 to figure 8 shows DCR of most effect member at different location. DCR are exceeding limit in both the approaches, progressive collapse will start. Figure 9 to figure 12 represent the DCR of column at Column Removed at Corner column, edge column, intermediate column and rentrant column respectively in building without dampers using LSA and LDA approach.

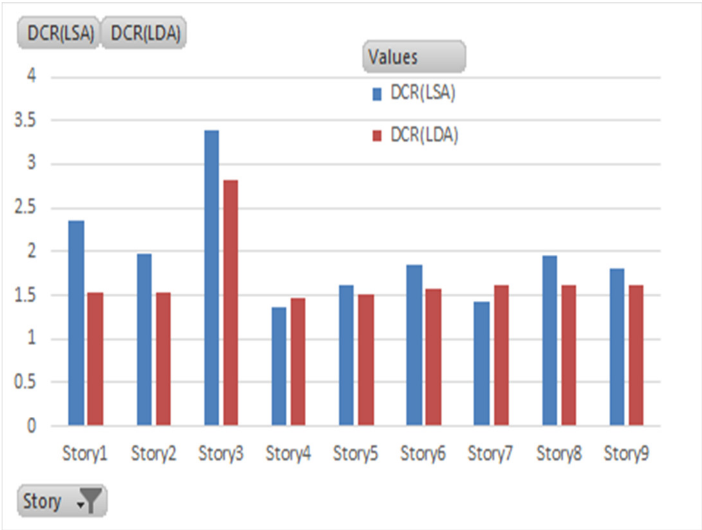

Figure 9 DCR of column at Column Removed at Corner column

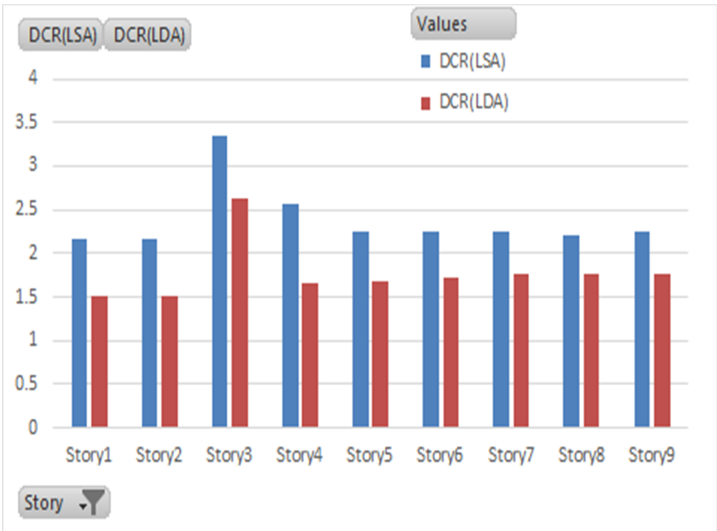

Figure 10 DCR of column at Column Removed at edge column

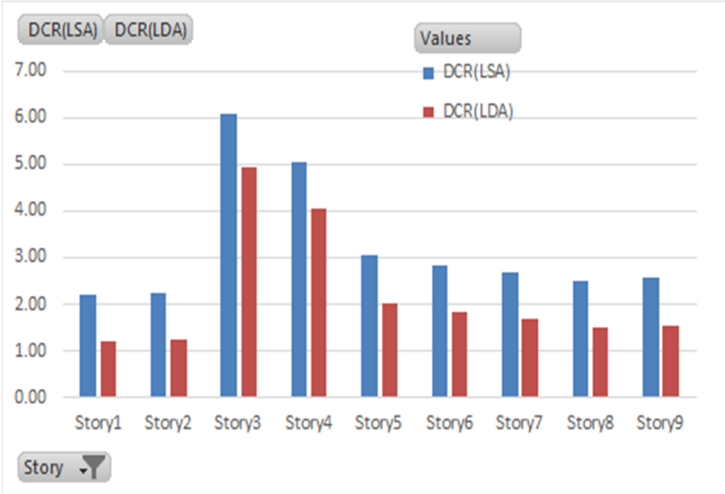

Figure 11 DCR of column at Column Removed at intermediate column

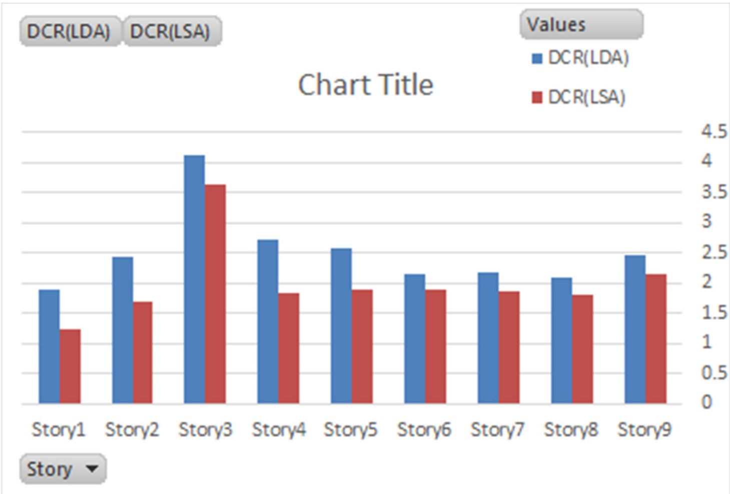

Figure 12 DCR of column at Column Removed at rentrant column

Figure 13 to figure 16 represent the DCR of beam at Column Removed at Corner column, edge column, intermediate column and rentrant column respectively in building with dampers using LSA and LDA approach.

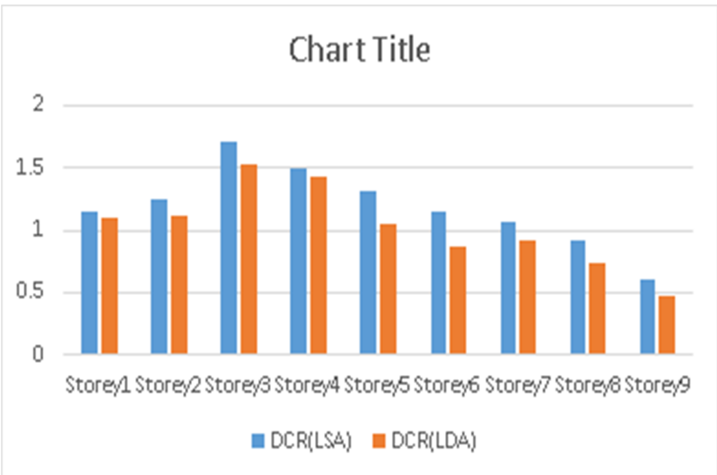

Figure 13. DCR of beam at Column Removed at Corner column

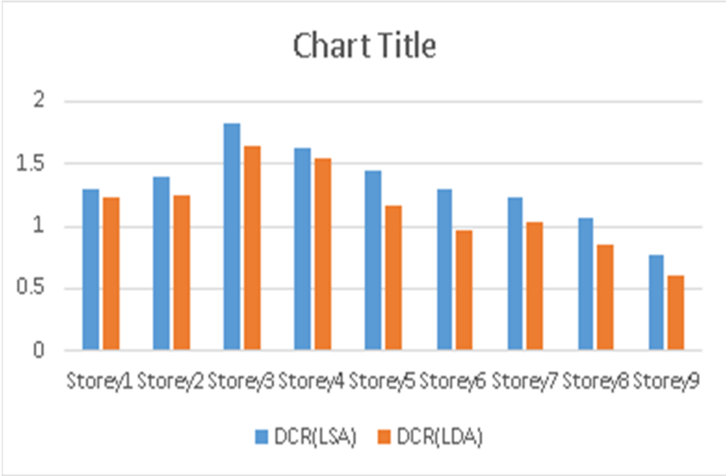

Figure 14. DCR of beam at Column Removed at edge column

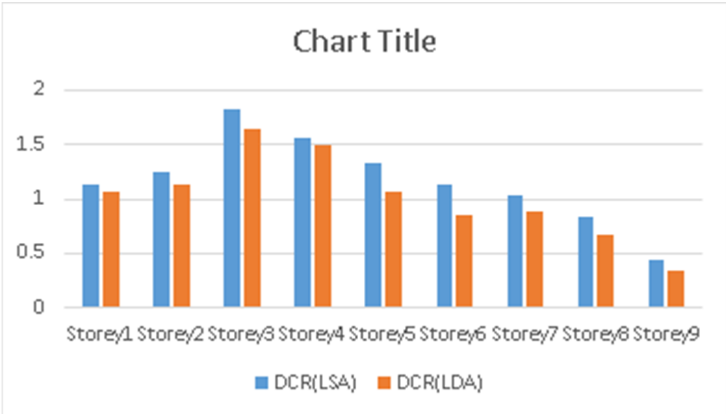

Figure 15. DCR of beam at Column Removed at intermediate column

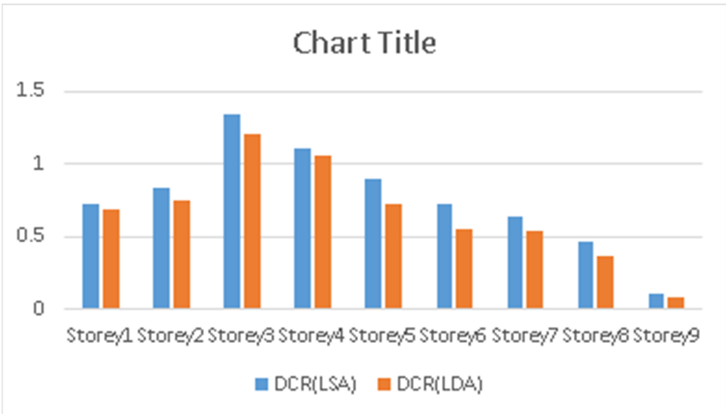

Figure 16. DCR of beam at Column Removed at rentrant column

Figure 13 to figure 16 shows DCR of most effect member at different location. DCR are within limit in both the approaches, progressive collapse will not start. Figure 17 to figure 20 represent the DCR of column at Column Removed at Corner column, edge column, intermediate column and rentrant column respectively in building with dampers using LSA and LDA approach.

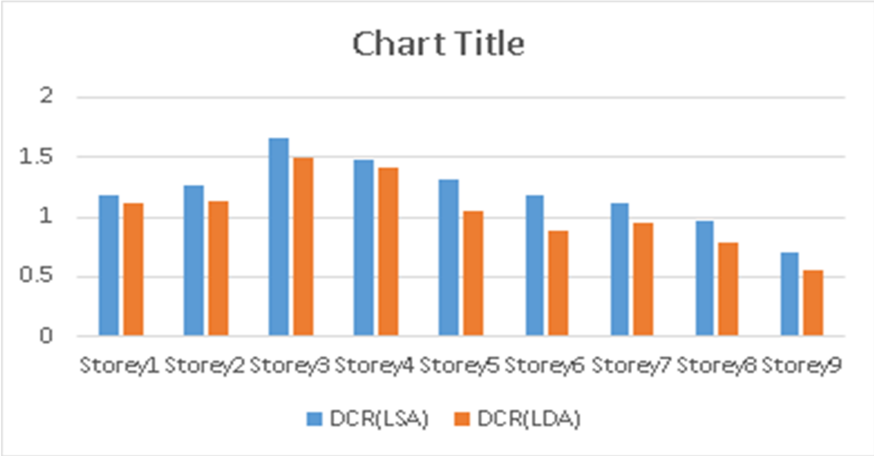

Figure 17. DCR of column at Column Removed at Corner column

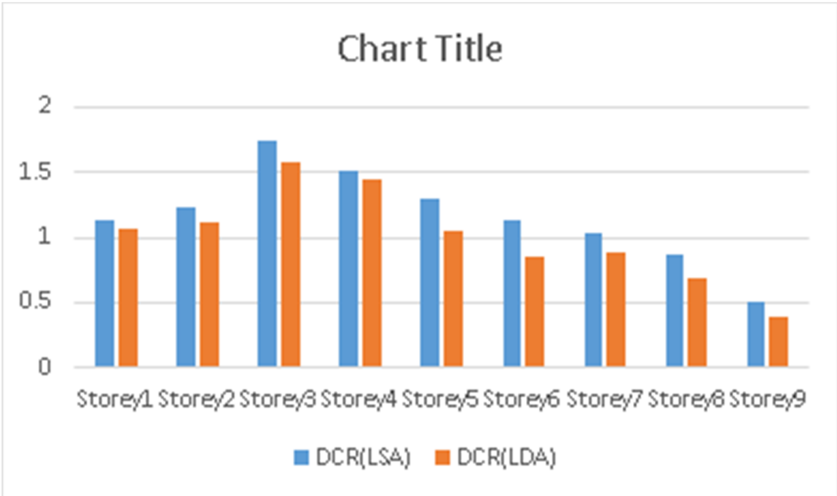

Figure 18. DCR of column at Column Removed at edge column

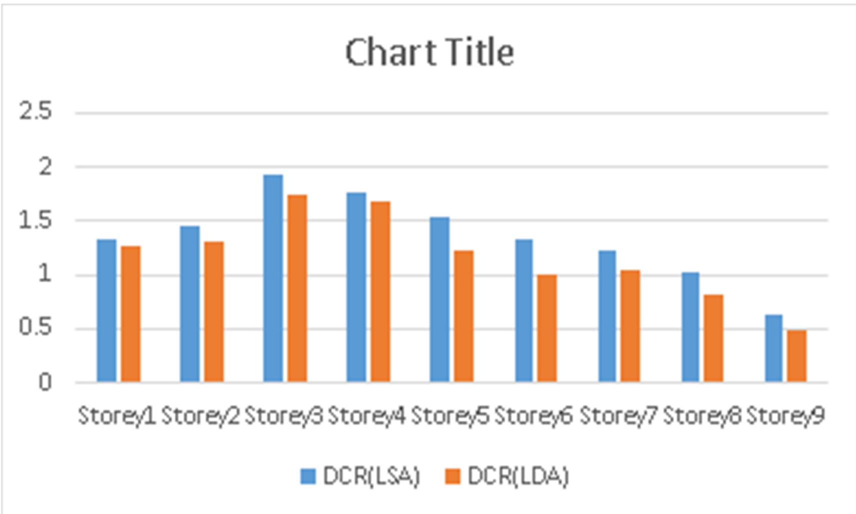

Figure 19. DCR of column at Column Removed at intermediate column

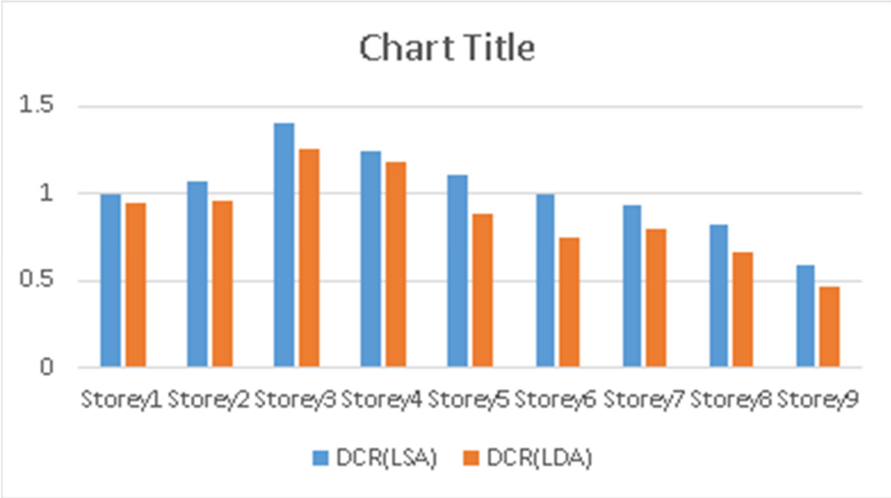

Figure 20. DCR of column at Column Removed at rentrant column

Figure 17 to figure 20 shows DCR of most effect member at different location. DCR are within limit in both the approaches, progressive collapse will not start.

4. CONCLUSION

This study demonstrated the progressive collapse behavior of a RCC transfer girder system building using ETABS software. In order to improve the progressive collapse resistance of structures in buildings and reduce the DCR values there are possible options .One option is increase a size of the member. Second option is use bracing and other option is use passive energy dissipation devices in irregular building LDA approach is more realistic than LSA. Using viscoelastic damper DCR value can be decreases .A part from this Viscoelastic damper also provide extra stiffness to the building, it helps in earth quake condition. Storey above the transfer girder has maximum DCR value compared to other storey. After removing intermediate column removal the building has more critical condition.

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